

# SCIENCE

# And Technology Program



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Earthquakes pose a major risk to public safety. Some Reclamations dams, especially older structures, could be significant hazards in earthquakes. Sudden failures are possible with short warning times and possible loss of life. This research program investigates some geotechnical aspects of earthquakes, namely soil liquefaction where soil loses strength rapidly.

Reclamation is investigating high hazard dams using penetration testing in the subsurface. The primary test is the Standard Penetration Test (SPT). For liquefaction analysis, the SPT "N" value requires an energy correction. Confusion exists regarding use of energy correction factors in the test. Dynamic stress wave and velocity energy are very difficult to measure, and over the last 20 years many different measurement techniques have been used. There has never been a detailed study of the correct instrumentation required. The American Society for Testing and Materials (ASTM) has decided not to standardize these measurements due to equipment variability.

There are many dangerous finer grained soils under our dams where the SPT cannot reliably predict liquefaction strength loss. Some of these soils include silts, windblown soils, slope wash soils, and volcanic ashes. These types of soils are under numerous dams. There is a need for new, more reliable methods to predict the earthquake behavior of these soils.

The first objective was to perform a comprehensive study of SPT energy measurement methods. This study will compare several systems that are used today and determine the exact requirements for successful, reproducible results. This study is currently being performed at the University of British Columbia at Vancouver, with in-kind assistance from British Columbia Hydro (BC Hydro). Results of this study will be completed in FY 2000.

To study behavior of fine grained soils, this program will test silts and low plasticity clays in the laboratory. Comprehensive testing will define the cyclic mobility of the soil depending on the "state" of the soil. Soils will be tested at differing consistencies. Engineers need to relate the laboratory behavior to actual field test data. Therefore, part of the study will consist of performing laboratory cone penetrometer and vane shear tests of the same soils at the varying consistencies. During the reporting period, we found two universities (University of California at Davis, and Virginia Tech) have already started a similar test program. Reclamation will build on these data by performing the model cone and vane tests. We will also test silt layers with the vane shear test at actual earthquake liquefaction sites in cooperation with the USGS in Menlo Park.

Windblown soils (Loess) and air fall volcanic ash are also present under some Reclamation dams in Nebraska, Oregon, and Washington. These low density soils could have very low strengths in earthquake loading. Loess samples from Bully Creek Dam, Oregon, have been taken, and Arizona State University has volunteered to test these samples for seismic stability.

The results of the SPT energy study will be reported in FY 2000. This program will finally help unify the SPT energy measurement methods through development of minimal instrumentation criteria for ASTM standardization.

There has been no program start on research on silts. A contract may be issued in FY 2000, depending on

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funding levels. The results of this study will allow engineers to reliably predict strengths of fine grained soils. This could result in large cost savings on dam modifications because very conservative methods are currently in use.

Studies of low density soils are just beginning. The results of this research will provide dam safety engineers with proven, less conservative methods for evaluating earthquake stability of these deposits.

Reclamation's Dam Safety Office; Pacific Northwest Region; U.S. Army Corps of Engineers, Waterways Experiment Station; U.S. Geological Survey, Menlo Park; B.C. Hydro; University of British Columbia, Vancouver; University of California at Davis; Virginia Technical Institute; Klonn Leonoff, Vancouver.

Reports from the SPT energy study will be issued in FY 2000 in the form of a university report and peer review report at the next Earthquake Engineering and Soil Dynamics Conference.